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[redacted]

Major Caliber HC Projectiles

- -

PART A

SYNOPSIS

1. This test was conducted to determine the fragmentation characteristics of 12" Mk 17 and 14" Mk 19 HC projectiles, Explosive "D" loaded.

2. a. The 12" HC projectile when compared to the 14" HC projectile produced about 35% more fragments weighing 2-1/2 to 640 grams and considerably less fragments weighing over 640 grams in polar angle zone 60° - 120°. About 85% of the projectile fragment weight of either projectile was expelled in zone 60° - 120°.

b. The 12" and 14" projectiles produced average median beam spray fragment velocities of 2140 ft/sec and 2210 ft/sec respectively.

[redacted]

TABLE OF CONTENTS

PART B

INTRODUCTION

1. AUTHORITY:

This test was authorized by reference (a) and conducted under Task Assignment NPG-36-Re3d-418-1 which was renewed by Task Assignment NPG-Re3d-418-1-53, reference (b).

2. REFERENCES:

a. BUORD Conf ltr S78-1(117) Re3d ANB:bc of 14 June 1949
b. BUORD ltr NP9 Re3d-ANB:bc of 29 July 1952
c. NPG Conf TelCon to BUORD S78-1(66-1) TZ:VW:ldd of 21 June 1950
d. BUORD Conf ltr S78-1(117) Re3d-ANB:bc Ser 46693 of 24 October 1952
e. NPG Report No. 129 of 19 October 1948

3. BACKGROUND:

a. Reference (a) requested that fragmentation tests of 12", 14", and 16" HC projectiles be conducted over the water pit with the projectiles in horizontal, base down and nose down positions. The tests requiring base down and nose down positions of the 14" and 16" projectiles were cancelled by reference (c) and the horizontal position test of the 16" projectile was cancelled by reference (d). This action was taken because of fragment hazard to nearby Naval Proving Ground installations and the possibility of damage to privately owned property.

b. Base fragment velocities of projectiles, 3" through 16", are being determined and will be the subject of a separate report.

4. OBJECT OF TEST:

This test was conducted to determine the fragmentation characteristics of 12" Mk 17 and 14" Mk 19 HC projectiles, Explosive "D" loaded.

5. PERIOD OF TEST:

a. Dates Project Letters	14 June 1949 21 June 1950 24 October 1952
b. Date Necessary Material Received	15 June 1949
c. Date Commenced Test	28 October 1949
d. Test Firing Completed (12" and 14")	14 June 1950
e. 16" Firing Cancelled	24 October 1952

PART C

DETAILS OF TEST

6. DESCRIPTION OF ITEM UNDER TEST:

a. 12" HC projectiles, Mk 17 Mod 2, Lot 4, Explosive "D" loaded and assembled with Mk 55 ADF and Mk 29 PDF, both modified for static detonation.

b. 14" HC projectile, Mk 19 Mod 4, Lot 13, Explosive "D" loaded and assembled with Mk 55 ADF and Mk 29 PDF, both modified for static detonation.

c. The projectile and explosive weights are as follows:

Rd. No.	Proj.	Firing Position	Empty and fuzed wt. (lbs)	Exp. "D" wt. (lbs)	Total wt. (lbs)	Frag. No.
1	12"	Horizontal	856.8	79.4	936.2	1421
2	"	"	855.8	"	935.2	1422
3	"	"	854.8	"	934.2	1423
4	"	Base Down	854.8	"	934.2	1425
5	"	Nose Down	856.8	"	936.2	1429
1	14"	Horizontal	1170.0	104.2	1274.2	1450
2	"	"	1164.2	"	1268.4	1460
3	"	"	1168.1	"	1272.3	1479

7. DESCRIPTION OF TEST EQUIPMENT:

a. Water Pit: A 15' square opening at ground level leading into a 20' square by 10' deep chamber filled with water. Projectiles are suspended directly above the opening by the use of a horizontal beam, such that (1) if the projectile is in a horizontal position, 1/6 of the fragments in the zone 60° -120° are trapped in the water pit, (2) if the projectile is suspended in a nose down position, all of the fragments in the zone 0° -30° are trapped in the water pit, and (3) if the projectile is suspended in a base down position, all of the fragments in the zone 150° - 180° are trapped in the water pit. All zones are polar angle zones measured from the nose, 0°.

b. 20' high vertical steel panels 80' from the projectile in zone 91° - 104° were utilized for fragment velocity determinations along with a 35mm Fastax Camera. A photograph of the water pit set up is shown in Figure 1.

8. RESULTS AND DISCUSSION:

a. Mass distribution for zone 60° - 120°: The recovered fragments are shown in Figures 2 to 9, inclusive, and the detailed mass distribution data are listed in Tables I and II. The summarized data are as follows:

Fragment wt. group (grams)	1/6 of Total No. Fragments in Zone 60° - 120°.		
	12" HC		14" HC
	Rd. 1	Rd. 2 & Rd. 3 average	Rds. 1, 2, & 3 average
2-1/2 - 10	567	184	99
10 - 40	437	148	116
40 - 160	316	150	112
160 - 640	72	87	82
640 +	1	8	35

Round No. 1 of the 12" HC projectile had a much finer fragment mass distribution than Rounds Nos. 2 and 3 and was not used in averaging the data. Metallurgical examination of the fragments of these projectiles (Appendix (D)) indicated that the only difference in properties was the distinctly greater brittleness of Round No. 1, as evidenced by the Charpy test. It is well known that a more brittle case material tends to give a finer fragmentation; for example, cast iron. Reference (e) indicated that the increased brittleness of a 5" projectile body caused by a decrease in its temperature was

reflected in a finer fragmentation. The anomalous results observed for Round No. 1 are therefore attributed to its brittleness. The 12" HC projectile (excluding Round No. 1) produced approximately 35% more fragments weighing 2-1/2 to 640 grams than the 14" HC projectile in polar angle zone 60° - 120°. About 85% of the projectile fragment weight of either projectile was expelled in zone 60° - 120°.

b. Mass distribution for zones 0° - 30° and 150° - 180°: The 0° - 30° fragments represent 1-1/2% and the 150° - 180° fragments represent 6-1/2% of the projectile fragment weight. The summarized data are as follows:

Fragment Weight Group (grams)	Total No. Fragments 12" HC	
	0° - 30°	150° - 180°
2-1/2 - 10	8	200
10 - 40	8	96
40 - 160	5	26
160 - 640	9	41
640 +	1	5

c. Fragment velocity: The detailed beam spray, 91° - 104°, fragment velocity data listed in Tables III and IV are summarized as follows:

Rd. No.	Median Fragment Velocity (ft/sec) 12" HC	14" HC
1	2110	---
2	2130	2230
3	2170	2290
Average	2140	2210

The above velocities are a mean measured over the first 80 feet of travel.

PART D

CONCLUSIONS

9. a. The 12" HC projectile when compared to the 14" HC projectile produced about 35% more fragments weighing 2-1/2 to 640 grams and considerably less fragments weighing over 640 grams in polar angle zone 60° - 120°. About 85% of the projectile fragment weight of either projectile was expelled in zone 60° - 120°.

b. The 12" and 14" projectiles produced average median beam spray fragment velocities of 2140 ft/sec and 2210 ft/sec respectively.

Major Caliber HC Projectiles

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By direction

U. S. NAVAL PROVING GROUND
DAHLGREN, VIRGINIA

Twenty-first Partial Report

on

Fragmentation Characteristics

- -

Final Report

on

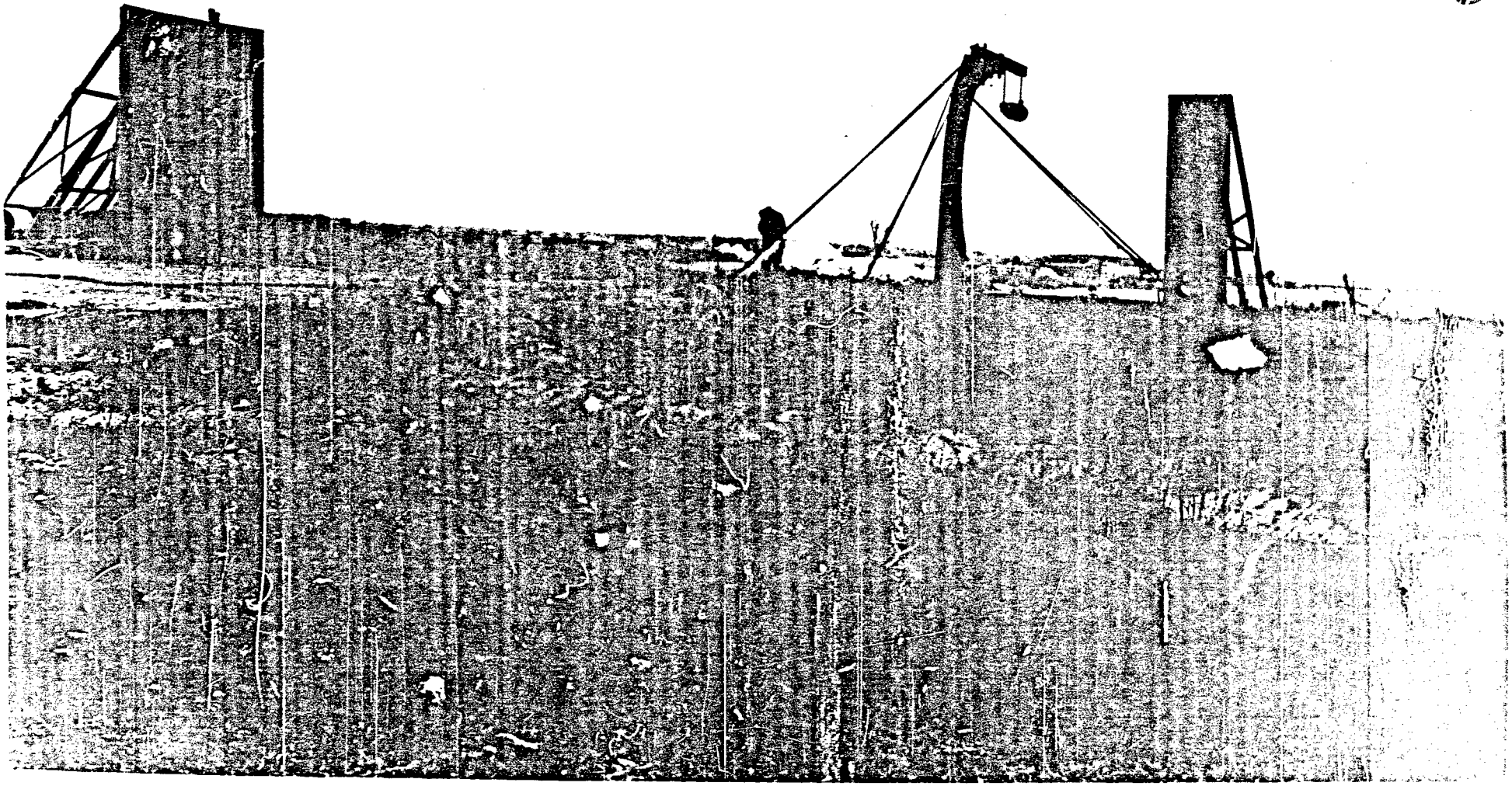
Major Caliber HC Projectiles

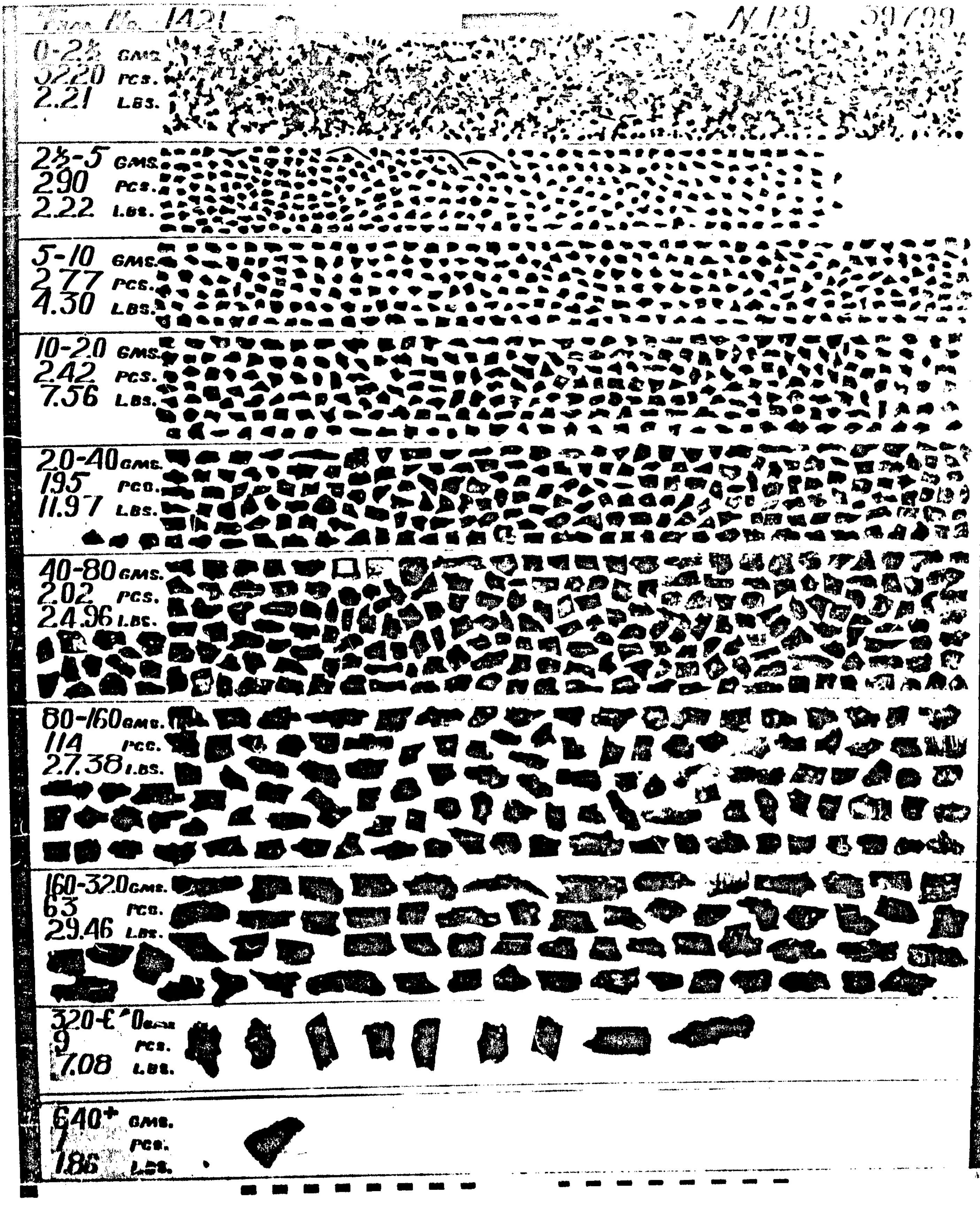
Project No.: NPG-Re3d-418-1-53
Copy No.: 12
No. of Pages: 8

Date: MAR 24 1953

Water Rig Set up for Static Detonation of 14" HC Projectile in Horizontal Position

FIGURE 1

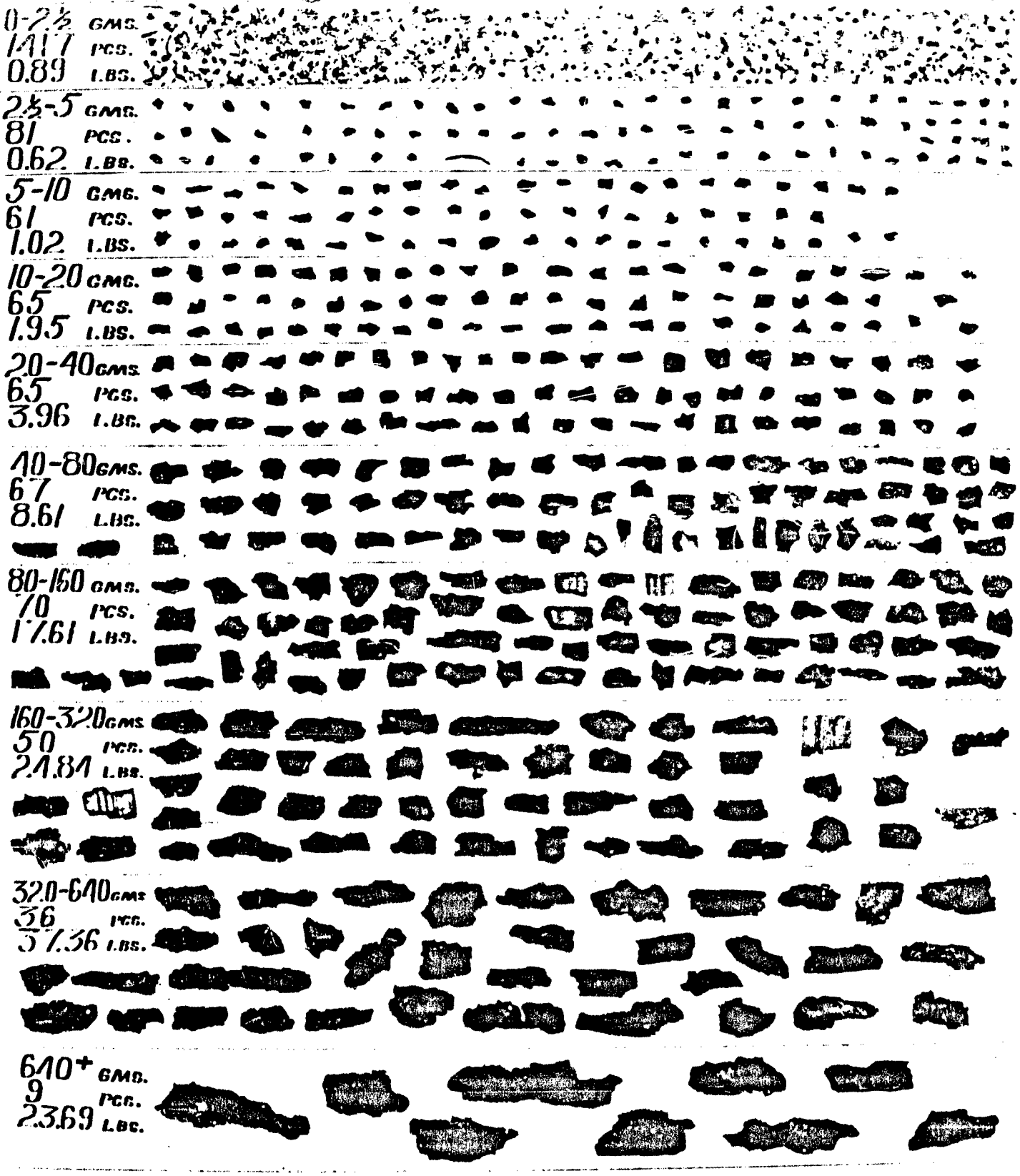




NP9-39799 28 ober 1949 CONFIDENTIAL SECURITY INFORMATION

d 1 12" HC Proj Mk 17 Fir n Horizontal Position Fragment Mass Distribution Water Pit Recove 2

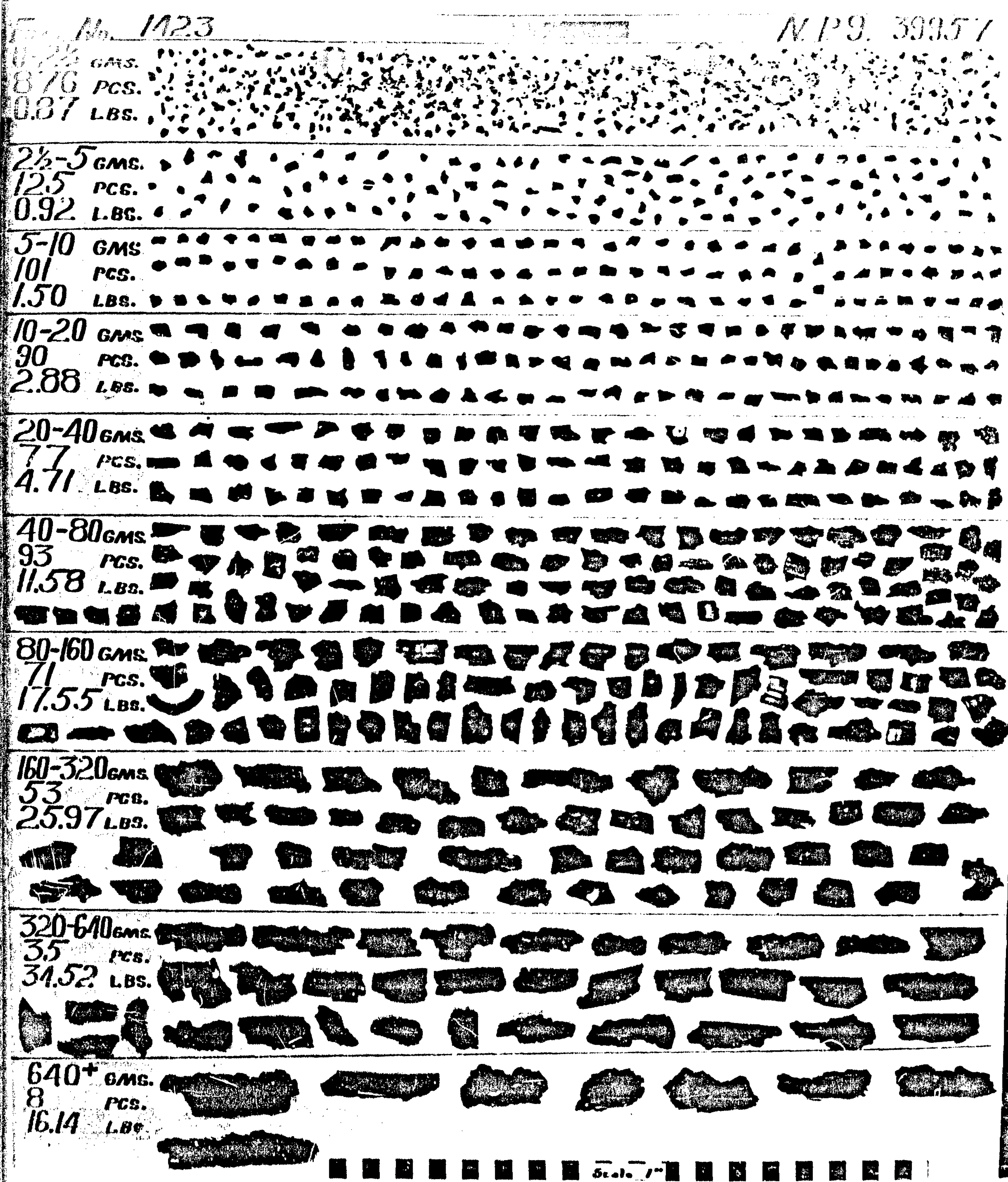
Frag No. 1422 NP9 39912



NP9-39912 4 November 1949 CONFIDENTIAL SECURITY INFORMATION

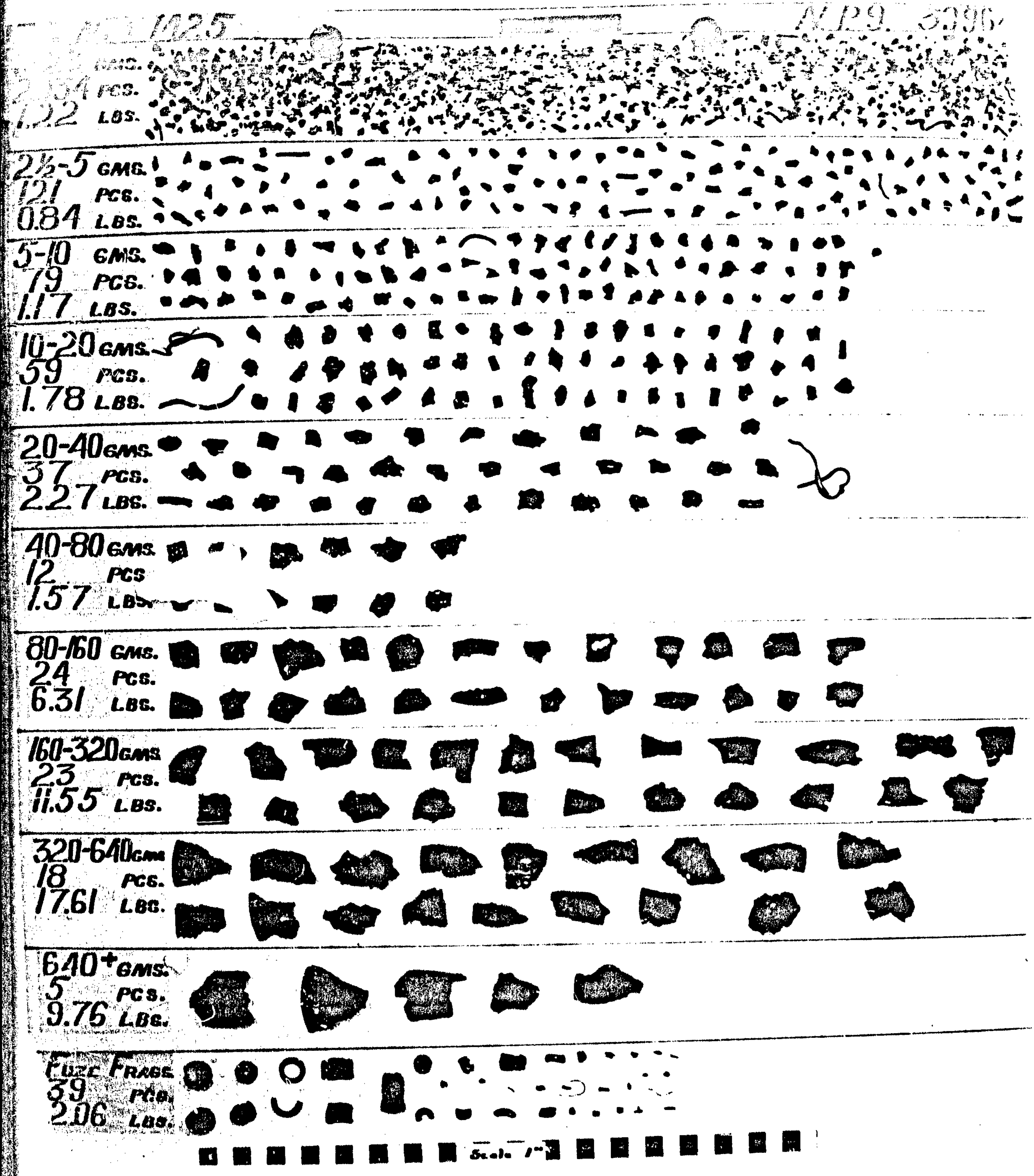
Rd 2 12" HC Proj Mk 17-2 Fired in Horizontal Position Fragment Mass Distribution Water Pit Recovery

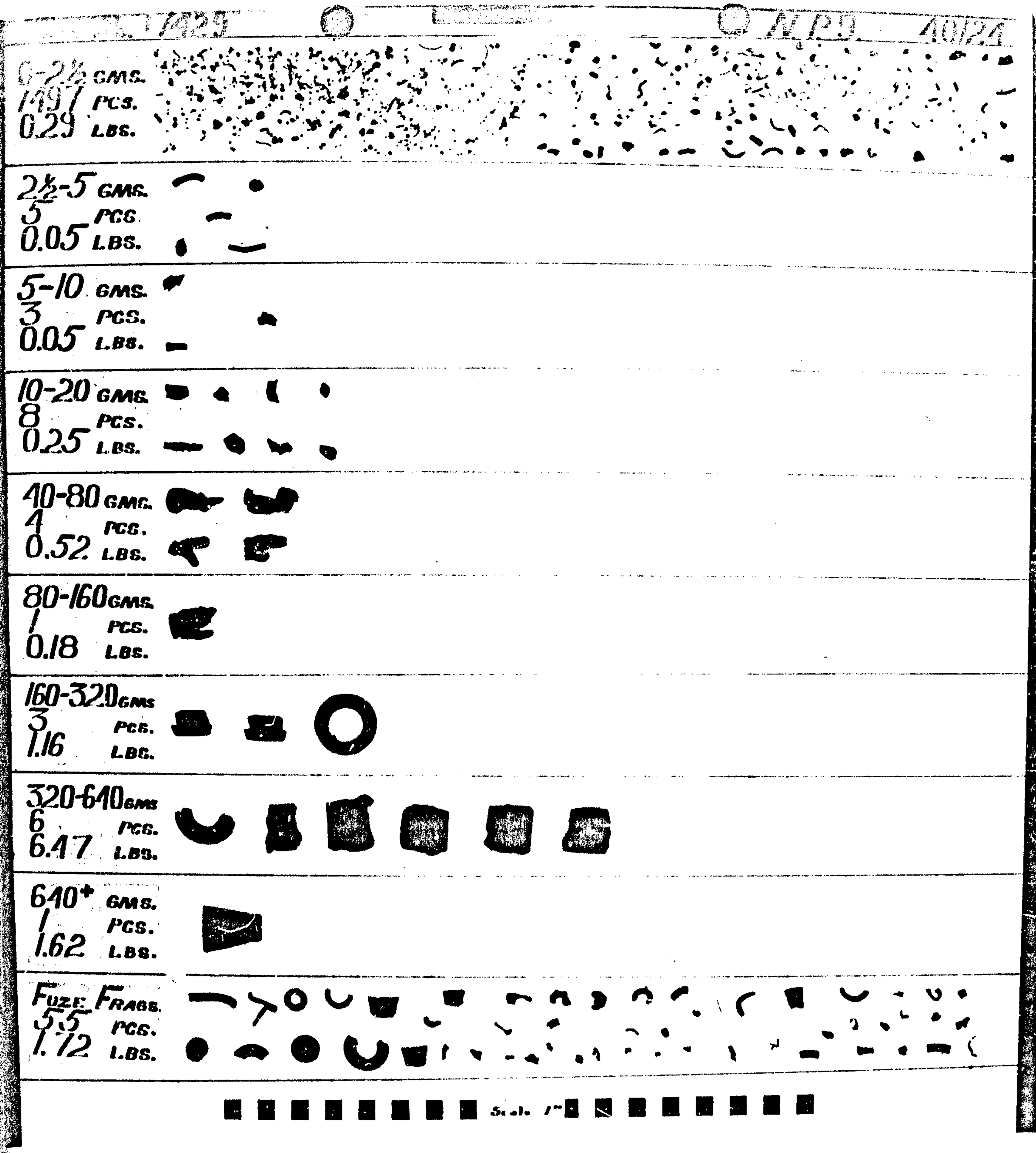
FIGURE 3



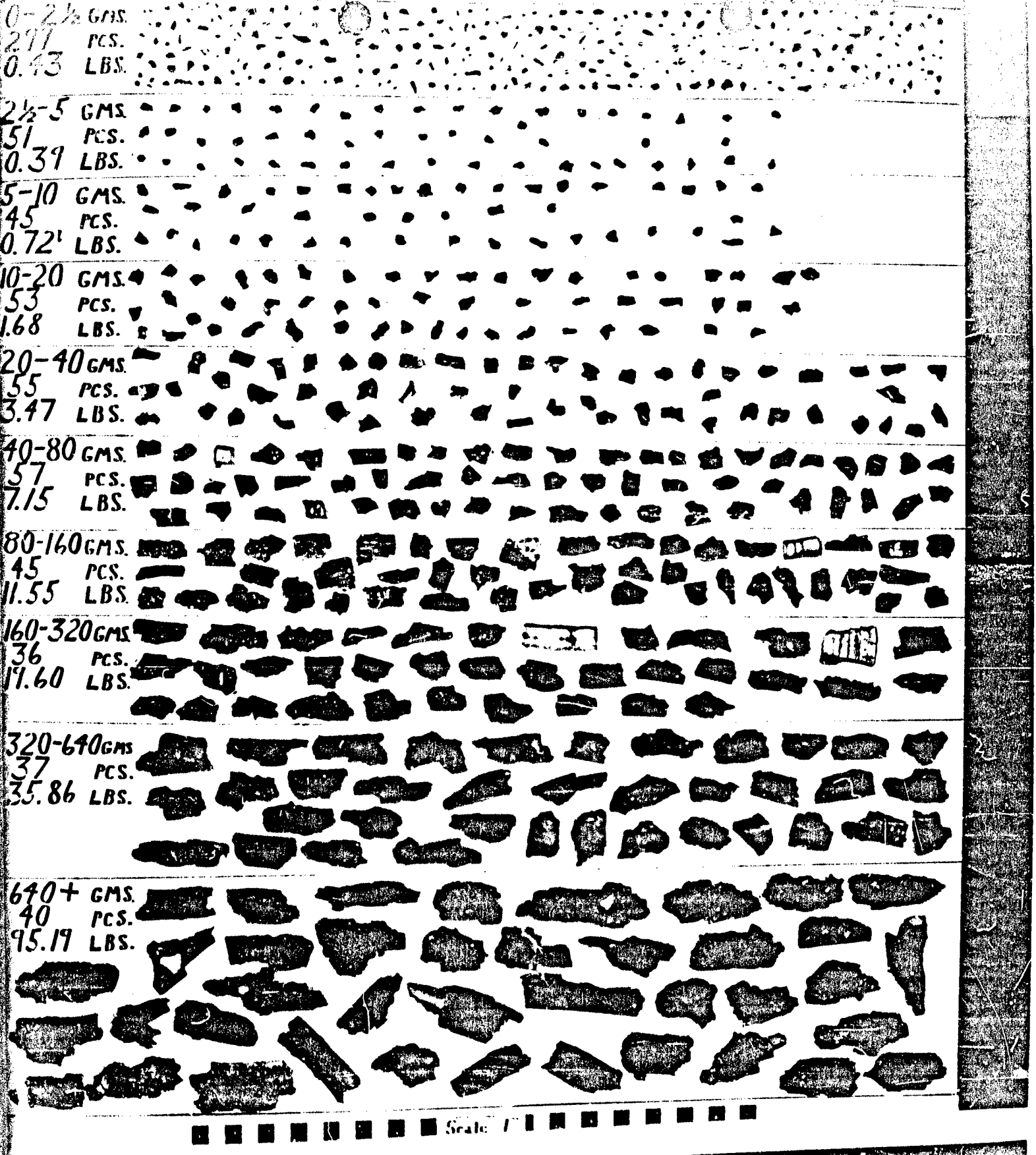
NP9-39957 ... (10 November 1949) ... CONFIDENTIAL

... Mk 17-2 ... fired in horizontal position ... recovery


1425
NP9 5396
GMS.
PCS.
1.22 LBS.
2½-5 GMS.
121 PCS.
0.84 LBS.
5-10 GMS.
79 PCS.
1.17 LBS.
10-20 GMS.
59 PCS.
1.78 LBS.
20-40 GMS.
37 PCS.
2.27 LBS.
40-80 GMS.
12 PCS
1.57 LBS.
80-160 GMS.
24 PCS.
6.31 LBS.
160-320 GMS.
23 PCS.
11.55 LBS.
320-640 GMS.
18 PCS.
17.61 LBS.
640+ GMS.
5 PCS.
9.76 LBS.
FUZE FRAGS.
39 PCS.
2.06 LBS.
Scale 1"



[illegible] 12[illegible] Proj Mc 17-2 Fired in Nose Down Position Fragment Mass [illegible]tribution Water Pit Recovery


0-2½ GMS.
277 PCS.
0.43 LBS.
2½-5 GMS.
51 PCS.
0.39 LBS.
5-10 GMS.
45 PCS.
0.72 LBS.
10-20 GMS.
53 PCS.
1.68 LBS.
20-40 GMS.
55 PCS.
3.47 LBS.
40-80 GMS.
57 PCS.
7.15 LBS.
80-160 GMS.
45 PCS.
11.55 LBS.
160-320 GMS.
36 PCS.
19.60 LBS.
320-640 GMS.
37 PCS.
35.86 LBS.
640+ GMS.
40 PCS.
95.19 LBS.

AMPS 11310

1½ GMS.
152 PCS.
0.33 LBS.

2½-5 GMS.
46 PCS.
0.37 LBS.

5-10 GMS.
48 PCS.
0.76 LBS.

10-20 GMS.
60 PCS.
1.94 LBS.

20-40 GMS.
73 PCS.
5.08 LBS.

40-80 GMS.
42 PCS.
5.20 LBS.

80-160 GMS.
55 PCS.
13.73 LBS.

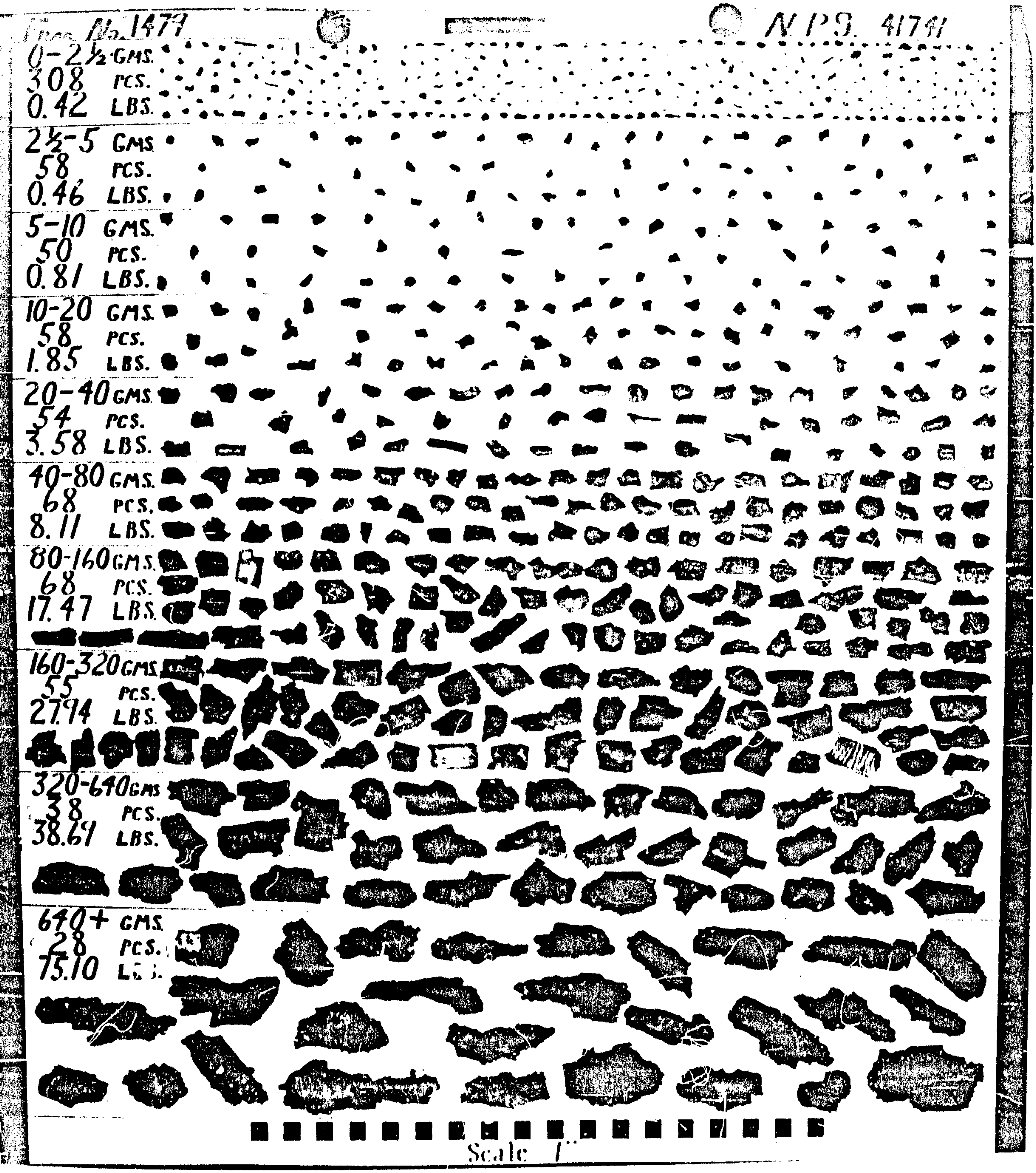
160-320 GMS.
51 PCS.
26.47 LBS.

320-640 GMS.
28 PCS.
27.83 LBS.

640+ GMS.
36 PCS.
85.44 LBS.

Scale 1

Fig. 5 Typical Horizontal Formation
After Pit Recovery



1944 Fired in Horizontal Position ... Mass
Distribution, Crater Pit Recovery

Figure 9

TABLE I

MASS DISTRIBUTION DATA

FRAGMENT MASS DISTRIBUTION, WATER PIT RECOVERY, 12" HC PROJECTILES, MK 17-2 EXPLOSIVE "D" LOADED

Rd. No.	Comp. Wt. lb.	Filler Wt. lb.	NUMBER AND WEIGHT OF RECOVERED FRAGMENTS 0-2.5 grams Wt. lb.	No.	2.5-5 grams Wt. lb.	No.	5-10 grams Wt. lb.	No.	10-20 grams Wt. lb.	No.	20-40 grams Wt. lb.	No.	40-80 grams Wt. lb.	No.	80-160 grams Wt. lb.	No.	160-320 grams Wt. lb.	No.	320-640 grams Wt. lb.	No.	640 + grams Wt. lb.	No.	Fuse Frag. Wt. lb.	No.	Total Wt. lb.	No.	Photo. No. NPG
Zone 60° - 120°																											
1	936.2	79.4	2.21	3220	2.22	290	4.30	277	7.56	242	11.97	195	24.96	202	27.38	114	29.46	63	7.08	9	1.86	1	-	-	119.00	4613	39799
2	935.2	79.4	0.89	1417	0.62	81	1.02	61	1.95	65	3.96	65	8.61	67	17.61	70	24.84	50	37.36	36	23.69	9	-	-	120.55	1921	39912
3	934.2	79.4	0.87	876	0.92	125	1.50	101	2.88	90	4.71	77	11.58	93	17.55	71	25.97	53	34.52	35	16.14	8	-	-	116.64	1529	39957
Total Rds. 2 and 3																											
	1869.5	158.8	1.76	2293	1.54	206	2.52	162	4.83	155	8.67	142	20.19	160	35.16	141	50.81	103	71.88	71	39.83	17	-	-	237.19	3450	-
Average Rds. 2 and 3																											
	934.7	79.4	0.88	1147	0.77	103	1.26	81	2.42	78	4.34	71	10.10	80	17.58	71	25.41	52	35.94	36	19.92	9	-	-	118.60	1725	-
Zone 150° - 180° (Base Down)																											
4	934.2	79.4	1.22	2034	0.84	121	1.17	79	1.78	59	2.27	37	1.57	12	6.31	24	11.55	23	17.51	18	9.76	5	2.06	39	56.14	2451	39964
Zone 0° - 30° (Nose Down)																											
5	936.2	79.4	0.29	1497	0.05	5	0.05	3	0.25	8	-	-	0.52	4	0.18	1	1.16	3	6.47	6	1.62	1	1.72	55	12.31	1583	40122

TABLE II

MASS DISTRIBUTION DATA

FRAGMENT MASS DISTRIBUTION, WATER PIT RECOVERY, 14" HC PROJECTILE MK 19-4 EXPLOSIVE "D" LOADED

Rd. No.	Comp. Wt. lb.	Filler Wt. lb.	NUMBER AND WEIGHT OF RECOVERED FRAGMENTS: 0-2.5 grams Wt. lb.	No.	2.5-5 grams Wt. lb.	No.	5-10 grams Wt. lb.	No.	10-20 grams Wt. lb.	No.	20-40 grams Wt. lb.	No.	40-80 grams Wt. lb.	No.	80-160 grams Wt. lb.	No.	160-320 grams Wt. lb.	No.	320-640 grams Wt. lb.	No.	640 + grams Wt. lb.	No.	Fuze Frag. Wt. lb.	No.	Total Wt. lb.	No.	Photo. No. NPG
Zone 60° - 120°																											
1	1274.20	104.2	0.43	299	0.39	51	0.72	45	1.68	53	3.47	55	7.15	57	11.55	45	19.60	36	35.86	37	95.19	40	-	-	176.04	718	41148
2	1268.4	104.2	0.33	156	0.37	46	0.76	46	1.94	60	5.08	73	5.20	42	13.72	55	26.47	51	27.33	28	85.44	36	-	-	167.15	595	41120
3	1272.3	104.2	0.42	308	0.46	58	0.81	50	1.65	58	3.58	54	8.11	68	17.47	68	27.94	55	38.69	38	75.10	28	-	-	174.43	785	41141
TOTAL 3815.0		312.6	1.18	763	1.22	155	2.29	141	5.27	171	12.13	182	20.46	167	42.75	168	74.01	142	102.38	103	255.73	104	-	-	517.62	2098	-
AVERAGE 1271.7		104.2	0.39	254	0.41	52	0.76	47	1.76	57	4.04	61	6.82	56	14.25	56	24.67	47	34.13	34	85.24	35	-	-	172.54	699	-

Major Caliber HC Projectiles

TABLE III

FRAGMENT VELOCITY DATA

Base Line: 80 feet
35mm Fastax Camera
Rd. 1 - 12" HC Mk 17-2
Total Weight 936.2 lbs.

3120 frames per sec.
Filler: Explosive "D"
Filler Weight 79.4 lbs.

Frame in Which Hit Occurred	Zone 91° - 104° No. Fragments	Velocity (f/s)
113	2	2210
114	2	2190
115	2	2170
116	2	2150
117	2	2130
119	4	2100
120	3	2080
121	2	2060
122	2	2050
123	1	2030
127	2	1970
128	1	1950
Median		2110
Average		2100

Major Caliber HC Projectiles

TABLE III (Continued)

Base Line: 80 feet
35mm Fastax Camera
Rd. 2 - 12" HC Mk 17-2
Total Weight 935.2 lbs.

3420 frames per sec.
Filler: Explosive "D"
Filler Weight 79.4 lbs.

Frame in Which Hit Occurred	Zone 91° - 104° No. Fragments	Velocity (f/s)
124	2	2210
126	2	2170
127	1	2150
128	1	2140
129	2	2120
130	3	2100
131	1	2090
132	2	2070
Median		2130
Average		2130

Major Caliber HC Projectiles

TABLE III (Continued)

Base Line: 80 feet
35mm Fastax Camera
Rd. 3 - 12" HC Mk 17-2
Total Weight 934.2 lbs.

3140 frames per sec.
Filler: Explosive "D"
Filler Weight 79.4 lbs.

Frame in Which Hit Occurred	Zone 91° - 104° No. Fragments	Velocity (f/s)
113	2	2220
114	3	2200
115	3	2180
116	3	2170
117	2	2150
118	2	2130
119	1	2110
121	1	2080
122	1	2060
123	2	2040
124	1	2030
Median		2170
Average		2140

Major Caliber HC Projectiles

TABLE IV

FRAGMENT VELOCITY DATA

Base Line: 80 feet
35mm Fastax Camera
Rd. 2 - 14" HC Mk 19-4
Total Weight 1268.4 lbs.

2100 frames per sec.
Filler: Explosive "D"
Filler Weight 104.2 lbs.

Frame in Which Hit Occurred	No. Fragments	Velocity (f/s)
73	2	2300
74	2	2270
76	2	2210
77	1	2180
78	1	2150
87	1	1930
88	1	1910
89	1	1890
Median		2230
Average		2150

Major Caliber HC Projectiles

TABLE IV (Continued)

Base Line: 80 feet
35mm Fastax Camera — 3030 frames per sec.
Rd. 3 - 14" HC Mk 19-4 — Filler: Explosive "D"
Total Weight 1272.3 lbs. — Filler Weight 104.2 lbs.

Frame in Which Hit Occurred	No. Fragments	Velocity (f/s)
106	1	2290
107	2	2270
108	1	2240
109	2	2220
110	3	2200
112	2	2160
113	1	2150
115	1	2110
116	3	2090
117	2	2070
Median		2190
Average		2170

Metallurgical Examination of Fragments from 12" HC Projectiles Nos. 1421 (Rd. No. 1), 1422 (Rd. No. 2), and 1423 (Rd. No. 3)

Chemical Composition:

A heavy fragment (320-640 grams) from each projectile was analyzed.

Projectile Number	C	Mn	P	S	Si	Ni	Cr	Mo
1421	.45	1.68	.030	.018	.19	.28	.98	under .10
1422	.41	1.55	.023	.011	.23	.19	.92	under .10
1423	.44	1.64	.028	.019	.23	.22	.98	under .10

There were no significant differences in the chemical composition of the three (3) projectiles. The steel was a manganese-chromium alloy type with residual nickel and molybdenum.

Hardness:

A fragment from the 160-320 grams group and from the 320-640 grams group of each projectile was sectioned and Vickers hardness tests were made on relatively undisturbed metal near the outside wall of the projectile.

Projectile Number	Vickers Hardness Number (20 kg.) 160-320 gms. Group	320-640 gms. Group
1421	260	253
1422	274	279
1423	296	315

Projectile No. 1421, which showed the finer fragmentation, apparently was a little softer than either of the other projectiles. However, Nos. 1422 and 1423 had a considerable difference in hardness which nevertheless did not affect their relative performance.

Impact Strength:

Charpy V-notch impact tests were made using 5 x 10 x 55 mm. specimens prepared from the larger fragments by selective machining. The test bars were cut longitudinal to the projectile axis and

Metallurgical Examination of Fragments from 12" HC Projectiles Nos. 1421 (Rd. No. 1), 1422 (Rd. No. 2), and 1423 (Rd. No. 3) (Continued)

were notched tangential to the projectile diameter on a 5mm face. In spite of some difficulties indicated by the data in Table (M-1), the results appeared to be significant particularly with regard to the estimation of per cent grain on the fracture surfaces. The test values were plotted in Figure (M-1) to show the relation between impact strength and temperature.

The estimated transition temperatures for 50% grain--50% shear fractures were as follows:

Projectile Number	Transition Temperature (50% shear fracture)
1421	+155°C
1422	+ 90°C
1423	+100°C

Measured by the high transition temperatures, all three (3) projectiles would be classed as "temper brittle" but the relatively higher transition temperature observed for the steel of Projectile No. 1421 indicated a comparatively greater tendency toward brittle failure than for the other two (2) projectiles.

Macrostructure:

The fragments of Projectile No. 1421 tended to show a relatively greater tendency toward internal cracking as illustrated by the unetched section in Figure (M-2). The predominant mode of fracture was a radial type of cracking probably caused by tensile stresses in the expanding side wall at the beginning of detonation.

The macrostructure of the etched sections is illustrated in Figure (M-3). The fragments from Nos. 1421 and 1422 HC Projectiles showed both the original cast dendritic structure near the outer wall and the worked structure from forging along the inside wall. The No. 1423 fragment had a more extensively worked structure such as might have occurred near the base of the projectile.

Metallurgical Examination of Fragments from 12" HC Projectiles Nos. 1421 (Rd. No. 1) 1422 (Rd. No. 2), and 1423 (Rd. No. 3) (Continued)

Microstructure:

The photomicrographs in Figure (M-4) indicated a quenched and tempered microstructure.

Projectile Number	Microstructure	Inclusion Rating (ASTM Globular Oxides)	Austenitic Grain Size	McQuaid-Ehn Grain Size
1421	Fully tempered structure.	No. 2 - thin	3-4	2-3
1422	Less tempered than #1421.	No. 4 - thin	3-4	3
1423	Less tempered than #1422 (and #1421).	No. 4 - thick	3-4	2

The amount of tempering decreased in the following order: #1421 - #1422 - #1423. This change corresponded to a gradual increase in hardness as indicated by the values given in Figure (M-4).

The inclusion rating, although based on a limited sample size, showed a gradual increase of inclusion content in the order: #1421 - #1422 - #1423.

A coarse grain size was observed in all three (3) samples.

Discussion:

The body of the 12" HC Projectile No. 1421--with the most desirable fragment distribution--was softer, had a more ductile microstructure and was a cleaner steel than that of the other test projectiles. However, Projectile No. 1422, which was intermediate in these same respects, had a fragment mass distribution almost exactly like that of No. 1423 and not at all like No. 1421. The only respect in which the latter projectile was observed to differ appreciably from the other two (2) projectiles was in the greater tendency toward brittle failure shown by the impact test.

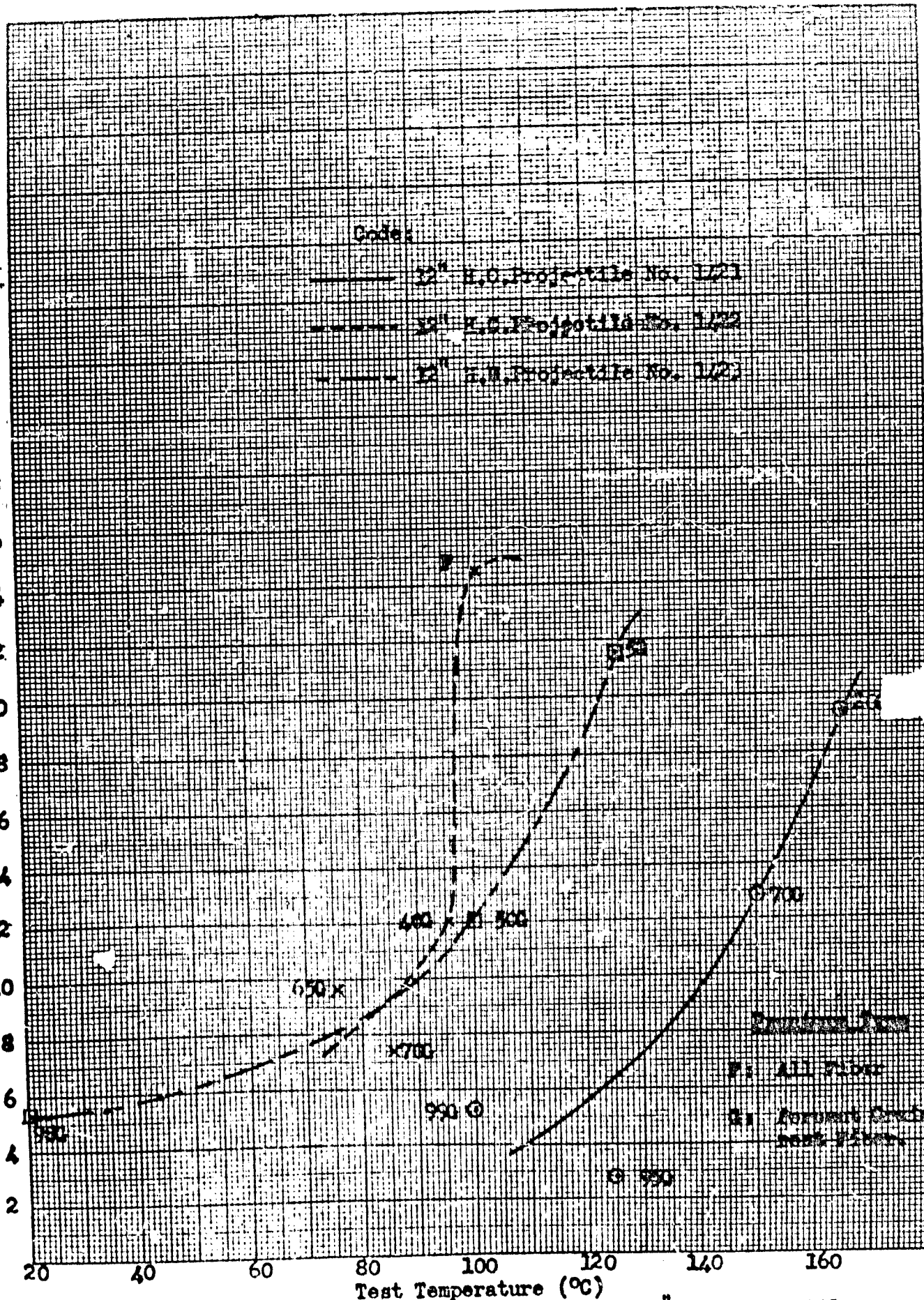
Metallurgical Examination of Fragments from 12" HC Projectiles Nos. 1421 (Rd. No. 1) 1422 (Rd. No. 2), and 1423 (Rd. No. 3) (Continued)

The other projectile steels were also temper brittle by ordinary standards without causing unusual fragmentation but it is possible that the relatively high order of brittleness in Projectile No. 1421 could have exceeded some critical value above which fragmentation might be affected. The finer fragmentation of 12" HC Projectile No. 1421 therefore may have been associated with a relatively greater tendency toward brittleness shown by the impact test.

Table (M-1) Charpy V-notch Impact Strength of Fragments from 12" HC Projectiles

Specimens: Standard except 5mm wide instead of 10mm
Machine: 30 ft.lb. capacity, velocity 15.12 ft. per second

Projectile Number	Test No.	Magnaflux Inspection Before Testing	Test Temp.(°C)	Charpy Impact Str.(ft/lb)	Fracture Rating	Remarks
1421	1	No cracks	+125	2.8	95% grain	
	2	Longitudinal cracks on back of test specimen	+100	5.2	99% grain	
	3	Light transverse cracks	+150	12.9	70% grain	Only 1/2 of section showed fresh fracture
	4	No cracks	+165	19.4	20% grain	
1422	1	Longitudinal cracks on back of test specimen	+ 75	9.7	65% grain	
	2	No cracks	+100	24.6	All fiber	
	3	No cracks	+ 85	7.3	70% grain	
	4	No cracks	+ 95	12.0	40% grain	
1423	1	No cracks	+100	12.0	50% grain	
	2	No cracks	+125	21.5	5% grain	
	3	Bad crack at root of notch	+ 22	5.3	98% grain	Only 3/4 of section showed fresh fracture



Charpy V-Notch Impact Tests on Fragments from 12" H.C.Projectiles.

Figure (M-1)

NP9-43445

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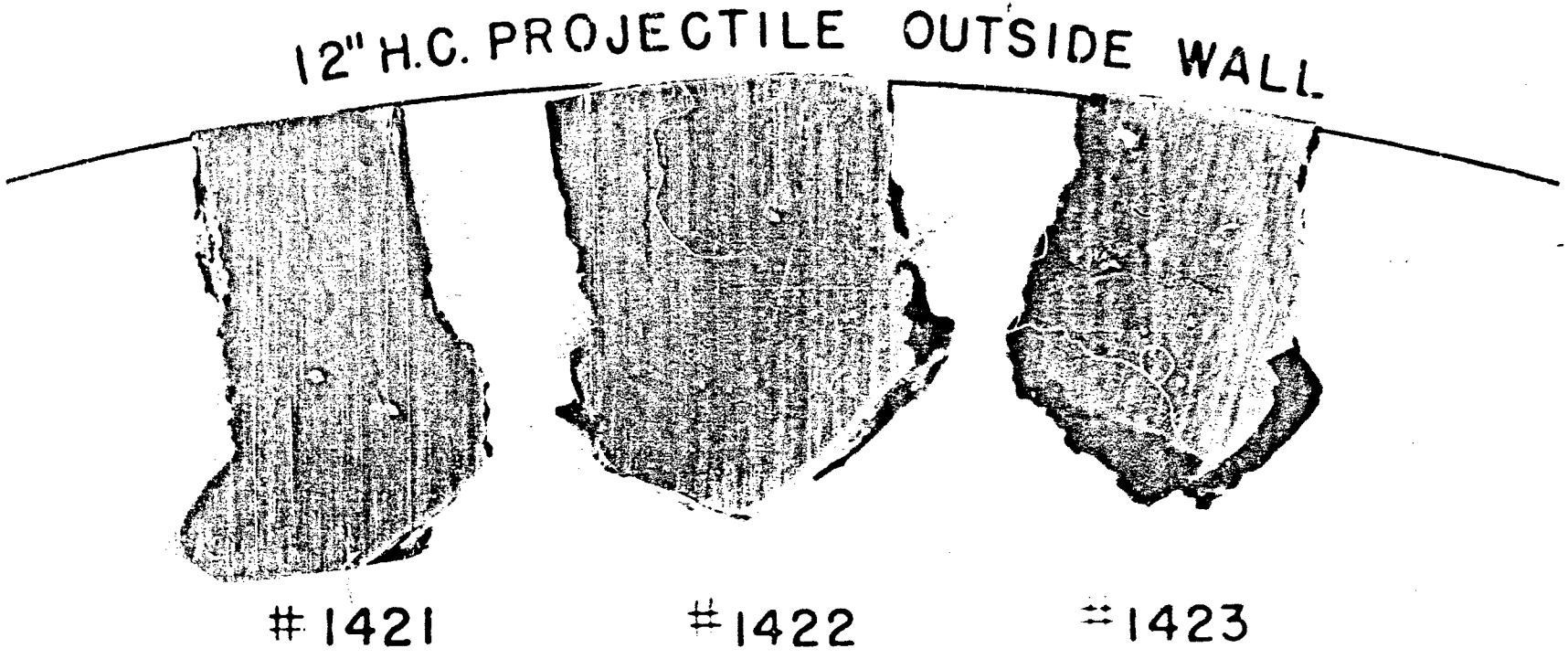
NP9-43406
Transverse Sections Through Typical Fragments in the 320-640 gms. Group, Showing Location of Fracture.
Unetched Magnification: 1 1/2 X



NP9-43407
Macrostructure of Transverse Sections Through Typical Fragments in the 320-640 gms. Group Showing the Dendritic Structure.

Magnification: 1 1/2 X

Etch: Ammonium persulfate

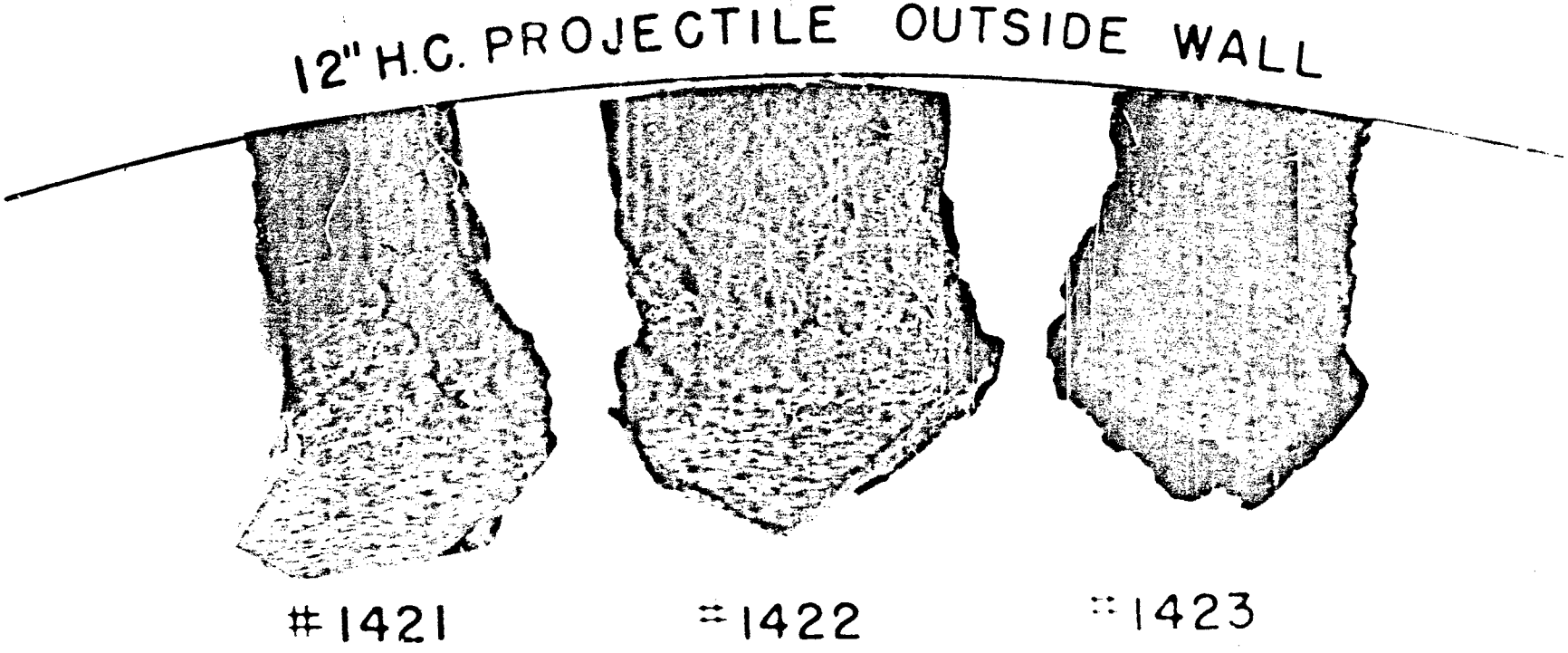
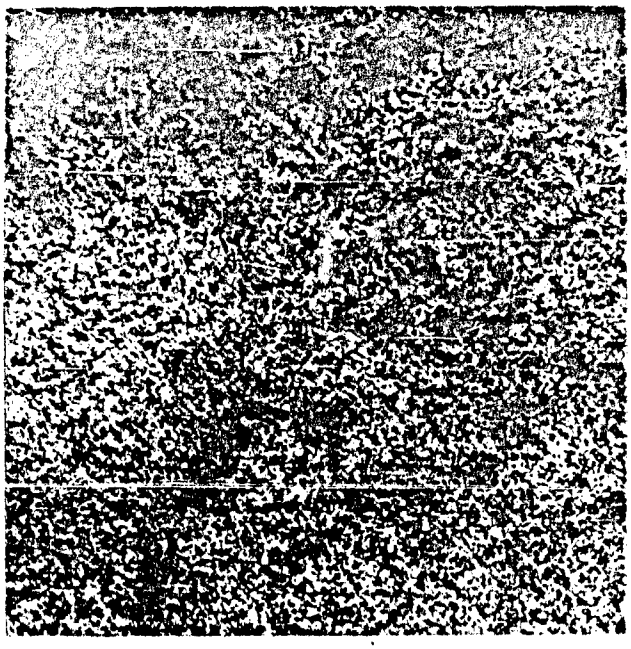


Figure (M-3)

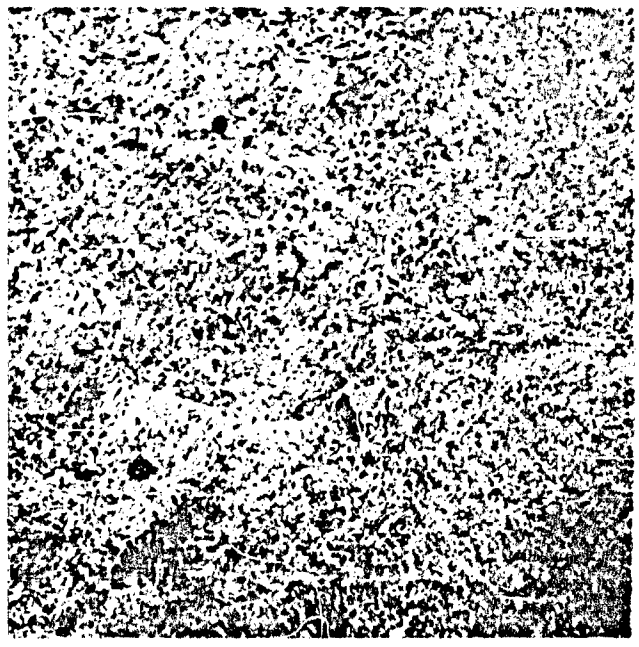
[redacted]

Major Caliber HC Projectiles



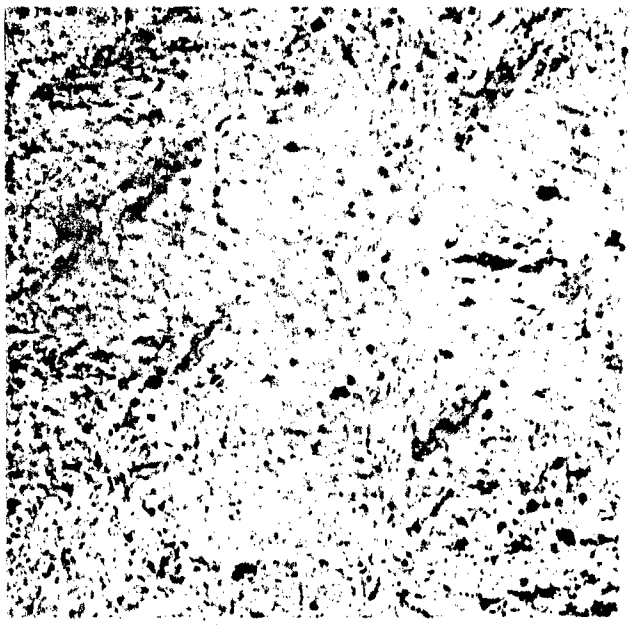
(A) NP9-43408

Projectile No. 1421
Hardness: 262 VPN (10 kg)



(B) NP9-43409

Projectile No. 1422
Hardness: 283 VPN (10 kg)



(C) NP9-43410

Projectile No. 1423
Hardness: 312 VPN (10 kg)

Microstructures in Side Wall Fragments from Three 12" HC Projectiles, Longitudinal Sections of 160-320 gms. Group.

Etch: Nital-picral. Magnification: 250X

[redacted] SECURITY INFORMATION

Figure (M-4)

[redacted]

Major Caliber HC Projectiles

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